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TECHNOLOGY UTILIZATION

MEASUREMENT TECHNOLOGY

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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TECHNOLOGY UTILIZATION OFFICE 1970
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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Foreword

The National Aeronautics and Space Administration and Atomic Energy Commission have established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace and nuclear communities. By encouraging multiple application of the results of their research and development, NASA and AEC earn for the public an increased return on the investment in aerospace and nuclear research and development programs.

This compilation is comprised of measurement methods and devices which have general application in industry. To assist the reader in finding items in his areas of interest, the material has been divided into four sections. Section one is devoted to the measurement of pressure and temperature and presents three devices and one concept. Section two presents considerations of the characteristics of fluids in the areas of flow and leakage rates and treats of systems and devices used to measure such activities. Surface measurements are covered in section three. Such criteria as flatness, concentricity, area, and contours are discussed, along with descriptions of the devices and techniques used in their determination. Section four contains twelve items that deal with linear and angular measurements. In this section, determinations are made of depth, length, width, height, and the methods and hardware used in their implementation.

Additional technical information on individual devices and techniques can be requested by circling the appropriate number on the Reader's Service Card included in this compilation.

Unless otherwise stated, NASA and AEC contemplate no patent action on the Technology described.

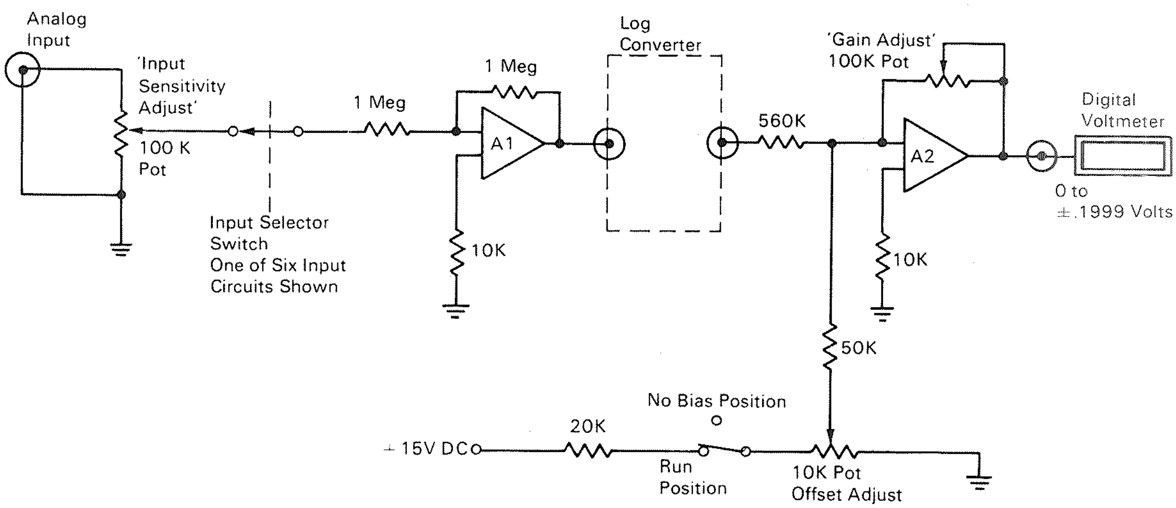
We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

Ronald J. Philips, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

Contents

Section 1. Measuring Pressure and Temperature

DIGITAL METER MEASURES SOUND PRESSURE LEVEL



Acoustical testing requires generators capable of a very wide range of noise levels. Microphones used in the recording of these signals must respond to changes as great as 10,000:1 or 80 dB in signal level. Microphone readout devices have, in the past, been calibrated in 20 dB increments, necessitating as many as 4 range changes during a single test.

A digital sound pressure level meter has been produced to provide an instantaneous display in engineering units of any desired analog transducer signal over an 80 dB range. The meter requires no manual range changing or scale corrections and it contains calibration networks for checking its accuracy over the entire operating range. The unit shows promise for any application requiring a rapid, unambiguous display in engineering units of a widely varying analog signal.

As shown in the figure, the meter is built around two operational amplifiers, a standard log converter, and a digital panel meter. Six normalized analog inputs (only one shown) permit switching between multiple microphone locations, as desired. The input operational amplifier (A1) serves to isolate the log converter from the microphone circuit, and to match the microphone output to the input amplitude range of the logarithmic converter.

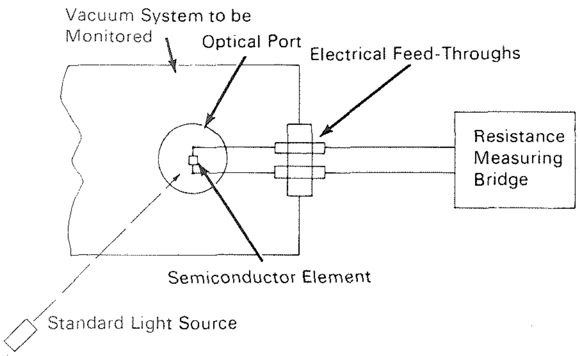
The log converter develops a continuous, true rms logarithmic analog of the microphone signal. This analog is then applied to the second operational amplifier (A2) which adjusts the output range of the log converter to match the range of the meter and provides isolation between the log converter output circuit, the digital voltmeter input circuit, and the adjustable bias offset circuit. This bias offset circuit acts to add an equivalent 100 dB value to the 80 dB dynamic range of the log converter, thereby providing a direct readout capability of 180 dB maximum sound pressure level from the digital voltmeter. A bias cutout switch is provided as an aid in calibration which is achieved by a logarithmic calibration unit internal to the log converter. This calibration unit provides six level steps in 20 dB increments to the log converter.

Source: H. D. Cyphers and A. Munson
Goddard Space Flight Center
(GSC-10987)

Circle 1 on Reader's Service Card.

CONCEPT FOR IMPROVED VACUUM PRESSURE MEASURING DEVICE

This concept for measuring vacuum pressures in the range from 5×10^{-7} to 5×10^{-6} torr should prove of interest to research and development manufacturers of vacuum tubes and related measuring devices. The basic element upon which the measuring concept depends is a semiconductor resistor, composed of sintered zinc oxide. Through the effect of surface adsorbed gases on the resistance of semiconductor materials, very low pressures can be measured. No existing techniques are capable of measuring low vacuum pressures below 10^{-14} torr. Above this pressure range, the standard procedure has been to employ some form of electron bombardment-ionization svstem.



Development of sensing elements uniquely sensitive to specific gas species has been an important contribution to research in measuring very low pressures. The key element should have a large surface-to-volume ratio, and the carrier concentration of electrons in the bulk which dominates the resistance characteristics of the specimen should be highly sensitive to the surface adsorption of the species to be measured.

There are several methods which can be used to measure very low pressures. One approach is to monitor the resistance of the semiconductor element as a function of time under the vacuum conditions to be monitored before, during, and after illumination by visible light of moderate intensities. This light source can be inside or outside of the vacuum system.

An alternate method is to substitute, for the standard light source inside the vacuum system, a simple filament placed in a pertinent geometrical relationship to the resistance element. This light source cleans the semiconductor surfaces by specific mechanisms. The decay or increase in the resistance following the cleaning procedure is then monitored by the resistance bridge. By means of appropriate calibration, a direct reading of the vacuum conditions can be obtained.

Another procedure substitutes heat for photon light and cleans the resistance element with temperatures in the vicinity of 400°C. This can be achieved by a second filament placed near the original filament. A heat sink contact and standard flashing techniques can also be employed.

Source: D. M. Medved of
Electro-Optical Systems, Inc.
under contract to
Marshall Space Flight Center
(MFS-20172)

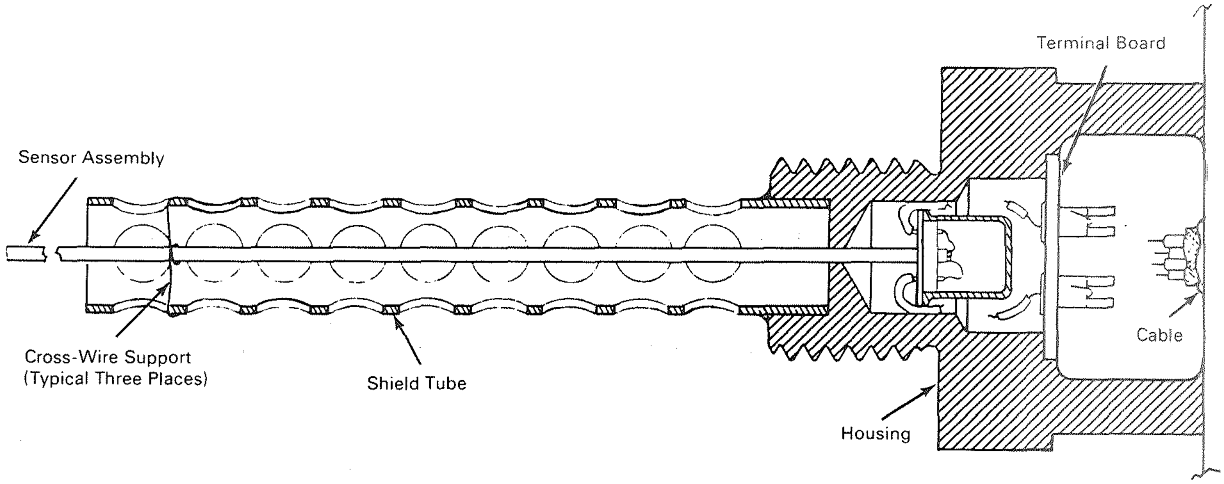
Circle 2 on Reader's Service Card.

GALLIUM ARSENIDE TEMPERATURE PROBE HAS FAST RESPONSE

An improved (faster response time) temperature probe has been developed for use in large tanks containing fluids at cryogenic temperatures. The probe has the following characteristics: temperature range from −440° to +300°F; accuracy of ±0.05°F; sensitivity of 0.1°F; and stability of ±0.001°F/6 months.

The probe has a time constant of 8 seconds or less to temperature step change when brought from liquid hydrogen, nitrogen, or oxygen to their respective still gases above the liquid. Without the shield tube, time constant is about 0.2 sec. The probe is a rugged instrument, being able to withstand 30 G's from 40 to 2000 cps and pressure to 3000 psi at cryogenic temperatures. The probe provides an output signal that can be transmitted by cable to an indicator as far as 2000 feet distant, and the signal is compatible with remote analog or analog-to-digital systems.

The sensing element is a forward-biased p-n junction device made with gallium arsenide. The diode chip is housed in a small stainless steel tube



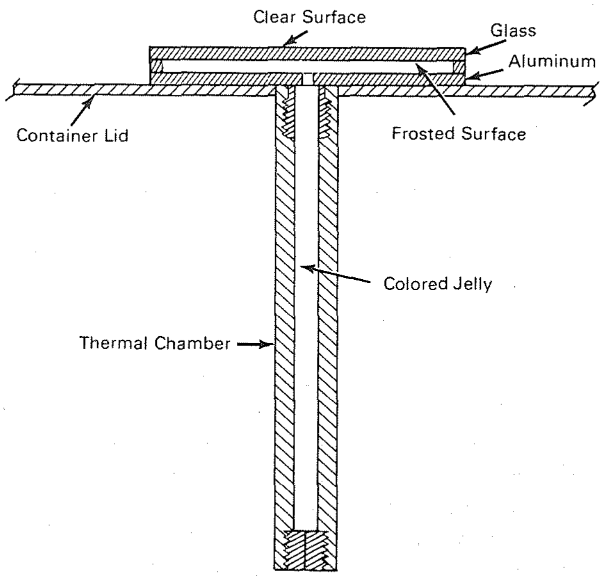
welded shut at the sensing end and supported by crosswires tied to a perforated shield tube. The diode is mounted on a thin gold-plated alloy ribbon (the cathode lead) with the anode connected by a gold wire to the anode lead at an insulated terminal board. The small cross section of the sensor tube and its effective insulation from its support structure result in its very rapid response to temperature changes.

Source: A. S. Benson of
Electro-Optical Systems, Inc.
under contract to
Marshall Space Flight Center
(MFS-12165)

Circle 3 on Reader's Service Card.

CRITICAL TEMPERATURE INDICATOR: CONCEPT

Certain substances require close temperature control between the time of preparation and the time of use. An example is a polymerizing adhesive that requires refrigeration from the time activators are added until usage.



A throw-away device has been conceived that indicates if a packaged (canned) substance has reached a temperature level that would adversely affect its quality. The principle of operation is the expansion of a colored jelly into a signal chamber at the top of a sealed probe. The probe is inserted into an opening in the container lid at the time of container filling and low temperature storage. When the temperature of the adhesive reaches the danger point, the colored jelly will expand into the capillary compartment of the probe and stain the frosted glass in the probe head.

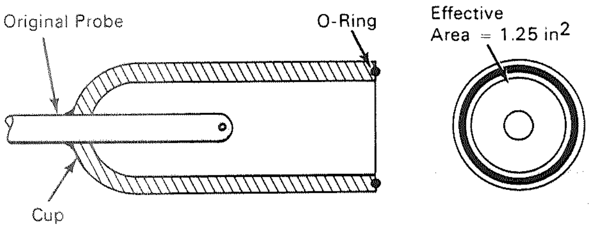
Source: L. Haffner of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-91449)

Circle 4 on Reader's Service Card.

Section 2. Measuring Fluid Activities

DETECTING AND MEASURING LEAKS IN THIN PLASTIC FILMS

Expulsion devices, such as bladders and diaphragms, used to forcibly empty liquified gas containers, usually consist of several plies of plastic film, each of which must be free of leaks. In conventional leak testing, the expulsion device is placed in a chamber and pressurized with helium gas. Gas accumulation in the chamber is then measured after a set passage of time (usually 24 hours). This method affords an accurate measurement of leakage rate but does not locate the leak position and is a time consuming operation.



Using an improved technique, individual plastic plies and the complete expulsion device can be checked for leaks by means of a helium leak detector. The expulsion device is pressurized with helium to 0.5 psig and, after a 30-minute waiting period, its entire surface is scanned with a modified helium mass spectrometer. Any standard mass spectrometer having a scale that registers 2×10^{-10} std cc/sec or less can be used. Modification to the probe, as shown in the figure, is in the form of a cup with a milled face that holds an O-ring in its end periphery which contacts the plastic film.

With one specific cup configuration, the mass spectrometer can measure helium leakage rates down to a level of 1.6×10^{-10} cc/sec/in^2. The cup enables the operator to locate and to measure the relative magnitude of a leak in a short time. The cross sectional area of the cup can be varied to meet different functional requirements.

Source: R. E. Nelsen and E. H. Nicholson of
The Boeing Company
under contract to
Lewis Research Center
(LEW-10530)

Circle 5 on Reader's Service Card.

SPIRAL-FLOW APPARATUS FOR MEASURING PERMEATION OF SOLIDS BY GASES

An apparatus has been developed for measuring the rate of permeation of a solid by a gas.

The novel test assembly consists of two portions machined from metal, a shallow top and a deeper bottom with matching flanges; their inner diameter is nominally 3.5 inches. In the inner face of the top, a knife-edged spiral groove is machined from the periphery to the center. At each end of the groove a hole is drilled through the face, tapped, and fitted with a sleeve.

A cylindrical plug of the solid to be tested (such as a polymeric material), 3.5 inches in diameter and 7/8 inch thick, is pressed into the top until the spiral knife edge engages its surface to a depth of 0.010 to 0.030 inch. The periphery of the plug is then sealed to the top with impermeable resin. The top and the bottom are then clamped together over a gasket with a Marmon clamp.

Under pressure the test gas is admitted to the bottom. A carrier stream of gaseous helium is passed through the outer sleeve of the top, along the spiral groove, and out through the central sleeve to a gas chromatograph that detects the presence of the test gas. Thus, the rate of permeation can be determined. Its spiral passage ensures that all of the carrier gas traverses the entire sur-

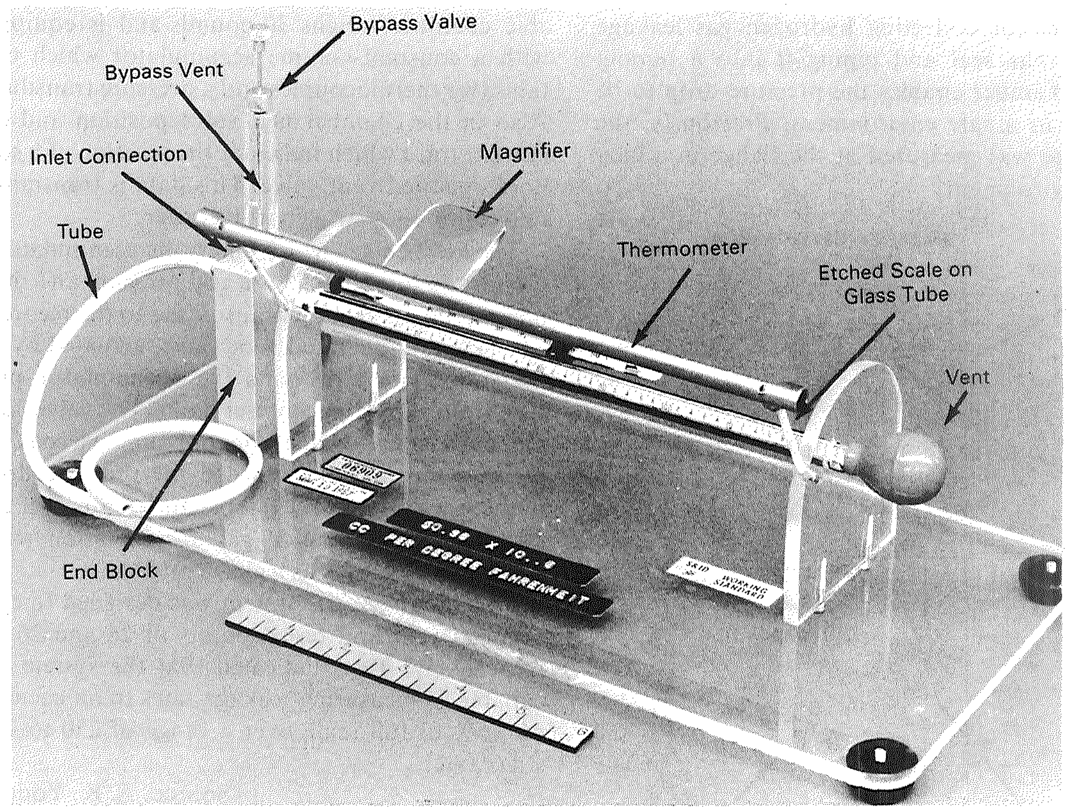
face of the solid and that all is sampled. The minimum detectable rate of permeation is 2.5×10^{-5} cm^3/sec (standard).

When tested for several days continuously, samples of a fire-retardent foam were impermeable by oxygen or nitrogen at 10 psig. When helium is the test gas, one of the sleeves in the top is sealed while the other leads to a helium mass spectrometer as a leak-detector. Samples of the same foam showed permeabilities by helium of 6.2 and 7.9×10^{-5} cm^3/sec (standard).

Source: S. M. Mitchell and B. B. Williams of North American Rockwell Corp. under contract to Marshall Space Flight Center (MFS-16517)

Circle 6 on Reader's Service Card.

DEVICE MEASURES GAS FLOW RATES IN 10^{-6} CC RANGE



A gas flow measuring device has been designed to give very low volume gas flow rates with a high degree of accuracy. The principal part of the device is a precision glass thermometer tube supported in a horizontal position. The tube is open at both ends and a small amount of mercury is inserted into the tube to create a seal. When a low volume of gas is introduced into one end of the tube, the mercury seal is displaced, thus providing a basis for measuring the gas flow rate.

A precision-bore glass tube, with a 0.0007-cm diameter bore and 25.4 cm long, is attached to a stainless steel tube horizontally mounted in plastic holders. One end of the glass tube is secured in an aluminum block that contains an inlet port and connects with a bypass valve. The other end of the tube is open to the atmosphere through a vent.

A scale, divided into 80 major divisions, is etched on the glass tube. Each major division represents 50.9×10^{-6}cc of volume, and is further

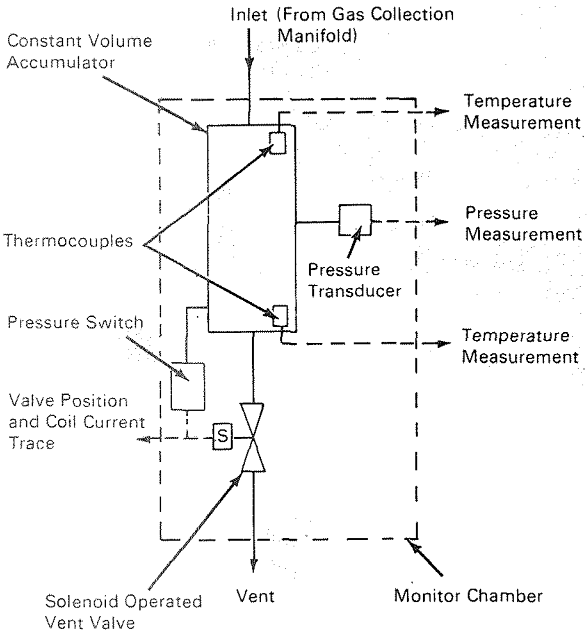
divided into five equal parts. An adjustable magnifying glass is mounted above the tube for easy reading of the scale. The gas flow being measured is connected to the inlet side of the glass tube with the bypass valve left open until a stable flow is established. The bypass valve is then closed, permitting the unknown gas volume to drive the mercury seal along the tube toward the vent. By timing the rate of travel of the seal, low flow rates in the 10^{-6} cc range can be determined. Any suitable timing device can be used to measure seal travel along the scale.

Source: T. J. B. Valdez of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11171)

No further documentation is available.

GAS LEAKAGE MEASURED IN REMOTE CHAMBER

A system for collecting hydrogen gas leakage from a flange seal and piping it into a remote monitor chamber enables the pressure drop to be measured in a safe environment. Previously, the gas leakage was measured at the flange in a hazardous environment.



The system includes a gas collection manifold which encloses the flange, so that leakage is piped into the remote monitor chamber. The portable chamber weighs 30 pounds and is equipped with a constant-volume accumulator which contains two thermocouples and a pressure transducer. Also in the chamber is a valve position and coil current trace which indicates the position of a solenoid-operated vent valve. This data is transmitted to a continuous strip chart recorder.

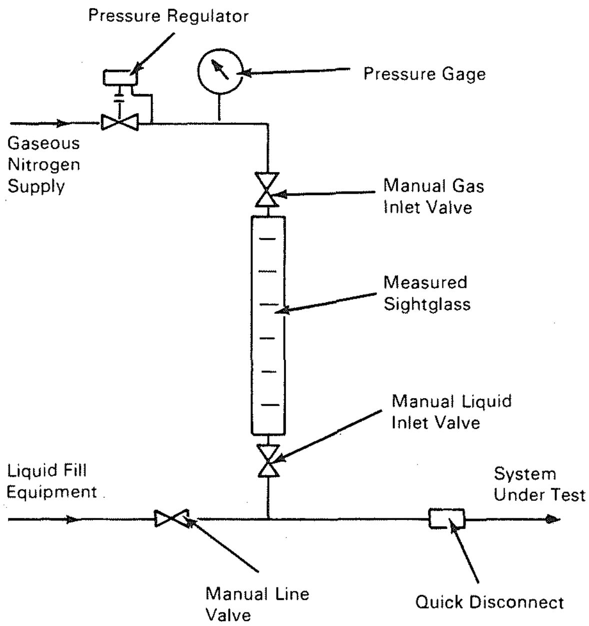
The escaped gas which enters the accumulator is monitored for temperature and pressure and these measurements also are transmitted to the recorder. The solenoid-operated vent valve, actuated by the pressure switch, prevents the accumulator pressure from exceeding a preset point. The valve automatically opens when the pressure exceeds the preset point and closes when the pressure drops to the reseat point. The data recorded are then used to calculate the rate of gas accumulation which corresponds to the gas leakage rate.

This hydrogen gas system was designed to cycle between vent and reseat points of 28 and 26 psi, respectively. Tests indicated that the system was capable of measuring leakage rates to an accuracy of ±5% of full scale over a range of 250 to 2500 std cc/sec.

Source: S. K. Yoder of
Aerojet General Corp.
under contract to
Space Nuclear Propulsion Office
(NUC-90064)

Circle 7 on Reader's Service Card.

ENTRAINED GAS MEASUREMENT SYSTEM



An apparatus has been built that permits the measurement of a volume of gas entrained in a closed liquid system. Previously, a filling procedure was followed that minimized the entrance of large quantities of gas, but provided no means of checking the amount of gas inadvertently introduced.

The equipment used in this apparatus includes: a manual line valve, a manual liquid inlet valve, a measured sightglass, a manual gas inlet valve, a gas pressure regulator and gage, and a nitrogen gas supply. The equipment is shown in its operational configuration.

To operate the apparatus, the sightglass is filled to about two-thirds capacity while the closed loop liquid system is completely filled. The line valve and liquid inlet valve are then closed and gas pressure is applied through the regulator until the gage shows 20 psig. Then the liquid inlet and gas inlet valves are opened and the liquid level in the sightglass is read. The pressure is increased to 30 psig and the sightglass level is again read. These data are then used in an application of Boyle's Law (a compressibility equation), to determine the volume of gas in the liquid system.

This apparatus can be used to check the amount of gas entrained in hydraulic systems, particularly where quantities of gas can cause failure in pumps and cooling systems.

Source: W. M. Mitchell of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-11166)

Circle 8 on Reader's Service Card.

Section 3. Surface Measurements

DUAL WAVELENGTH INTERFEROMETER: CONCEPT

In the construction of a large high performance parabolic reflector for a telemetry antenna or for an even larger reflector in the case of a radio telescope for celestial observations, it is necessary that the contour of the dish be precise. Interferometry, the conventional technique for measuring the concave reflecting mirror of an optical telescope, is not practical in this application because of the large dimensions involved.

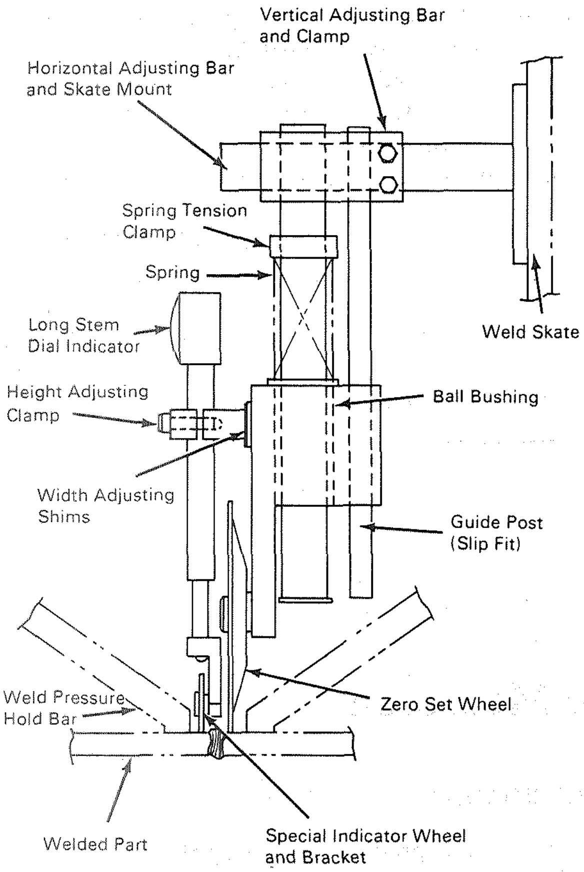
A new concept contemplates an interferometer with two light sources differing slightly in wavelength which could exceed the capabilities of a conventional instrument by several orders of magnitude. Such an instrument would record a

composite fringe pattern representing a much greater measurement capacity than the pattern from a single light source. This concept would be applicable to any measurement to be made with an optical interferometer. However, the concept is most readily explained by using the example of the measurement of a small angle between two reflecting surfaces. The angle can be calculated precisely if the wavelengths of the light sources and the number of fringes displayed are known. A limiting factor in the application of the instrument is the relatively short wavelength of visible light.

Source: R. E. Oliver of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11312)

Circle 9 on Reader's Service Card.

MOVABLE GAGE MEASURES BUTT WELD OFFSET



To measure the offset between two butt-welded panels, previous methods employed two gages set at an angle to each other. A new device has been fashioned that accomplishes a quick and direct measurement, on only one dial indicator, of any difference (offset) between the two butt-welded members' planes.

A long-stemmed dial indicator is operated by a surface contacting wheel and is mounted in a height adjusting clamp. This clamp attaches to a bracket and ball bushing arrangement that supports a large diameter (zero set) wheel that is held in intimate contact with one butt-welded member by imposition of a slight spring load. The vertical shaft and horizontal adjusting bracket are clamped as required for positioning in relation to an existing weld or trim skate to follow the butt joint. As the spring holds the large (zero set) wheel in contact with one panel surface, the small wheel attached to the dial indicator follows the opposite side panel surface, thus furnishing a direct reading of any offset between the two panels.

Source: D. R. Palmer of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-12688)

No further documentation is available.

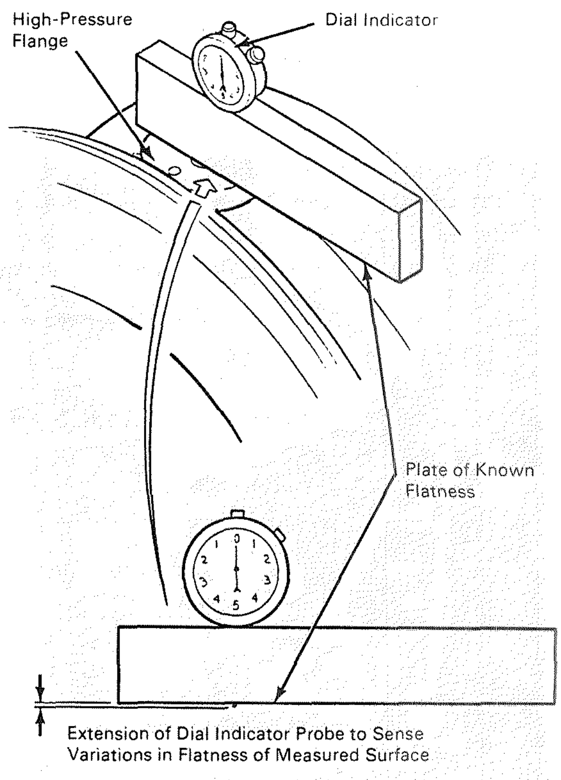
FLATNESS GAGE MEASURES DIRECTLY

Flanges in high-pressure piping systems must have mating surfaces with flatness that approaches that required in optical applications. The previous approach involved disassembly of leaky joint components and then making a flatness runout on a boring machine.

In order to avoid the costly, time-consuming disassembly and checkout procedure, a tool has been designed that gives a flatness check of these flange faces in place with only disconnection involved. The tool consists of a plate that is flat within 0.0001 inch and that is bored through to accommodate a dial indicator so that the tip of its probe extends a predetermined distance below the plate's flat surface. When the gage is moved over the surface of the flange face, an instant check of differences in flatness over the flange face is made by the dial indicator.

Source: A. Brooks of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13975)

No further documentation is available.



"NEGATIVE" RADIOGRAPHY MEASURES INACCESSIBLE OBJECTS

It is sometimes necessary to determine the dimensions of organic components within metallic housings and neutron radiography is useful for this purpose but is not generally available. By surrounding such organic components in a radiographically dense liquid, it is possible to radiograph them by ordinary X-ray techniques. If all cavities within the housing are filled with the dense liquid, a complete volumetric outline of the organic components can be obtained. Such an outline is in the form of a "negative" (dark) image in contrast to conventional radiography.

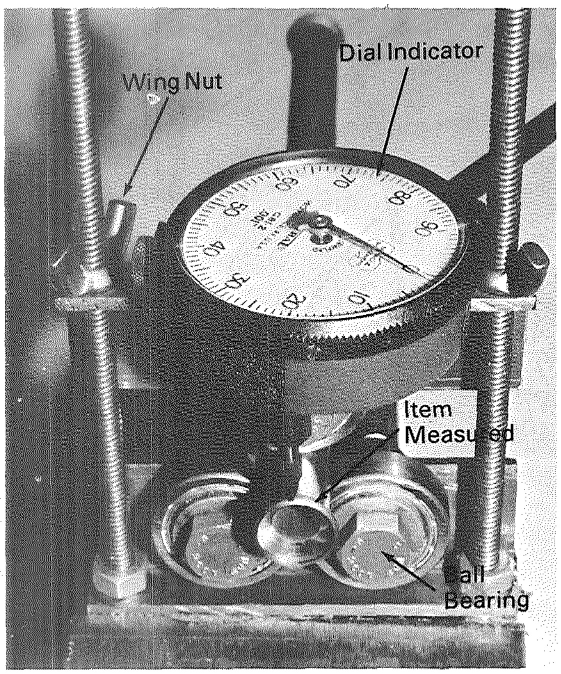
High-density fluids may be made by dissolving heavy metal salts in a carrier fluid, or by suspending finely-powdered materials in gels or emulsions. Such a dense compound as freon 114-B2 may be used, but its reaction to the organic components must be tested. This noncorrosive freon is a cleansing agent, and is thus preferred where proven inert toward the organics present.

Source: R. L. Brown, Sr.
Marshall Space Flight Center
(MFS-20528)

No further documentation is available.

INSTRUMENT ACCURATELY MEASURES CONCENTRICITY

An instrument has been developed to measure the concentricity of flared tubing ends. The instrument should find application in many industries as a rapid and accurate method to measure multiple concentric surfaces on any round base diameter. The tool-making industry and any industries involved with high pressure fluid transfer could benefit from the use of this instrument.



The instrument consists of three high precision ball bearings arranged in a vee that can be adjusted in size by raising or lowering a movable upper portion of the device. A dial indicator rides on the upper portion with its probe located above and outboard of the opening between the bearings. The item under test for concentricity measurement is placed above the two lower bearings and the upper portion is lowered until its bearing contacts the item. The wing nuts are tightened until firm contact is obtained between the item and the three bearings. The dial indicator probe is adjusted to contact the surface to be measured and the item is slowly rotated. Any movement of the indicator pointer shows a nonconcentric area.

Source: C. A. Goodwin of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10290)

Circle 10 on Reader's Service Card.

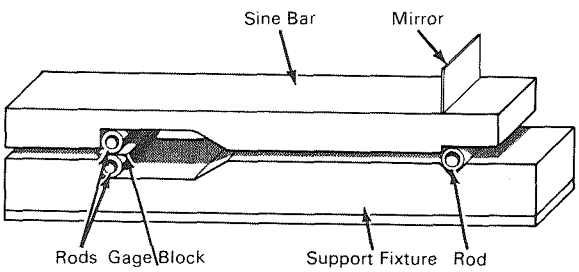
Section 4. Linear and Angular Measurements

MODIFIED SINE BAR DEVICE MEASURES SMALL ANGLES WITH HIGH ACCURACY

The principle of the sine bar has been adapted to the calibration of precision optical autocollimators. In this application, it was required to measure angles over a range of 1.00 arc-second in increments of 0.05 arc-second, with a maximum error of ±0.01 arc-second in any given increment.

The required measurement accuracy over this extremely small angular range was achieved with the sine bar device shown in the drawing. In this design, the sine bar is a massive bar of steel supported on a fixture by two cylindrical rods near the left end and by one cylindrical rod in a V-groove near the right end. By placing precision gage blocks between the rods on the left end, the sine bar may be made to rotate about the cylindrical rod on the right end. The effective length of the sine bar as measured by the distance between the axes of the cylindrical rods at either end is

20.025 inches. A mirror is rigidly fastened to the right end of the sine bar to deflect a beam of light through an angle twice that of the sine bar rotation. The autocollimator to be calibrated is placed in front of the mirror. Angles of the required magnitude and accuracy can be generated by a set of 20 commercially available gage blocks which are calibrated in increments of 5×10^{-6} inch, and are guaranteed in flatness and thickness to $\pm 10^{-6}$ inch. By replacing a gage block with another in the series, the normal to the mirror rotates in increments of very nearly 0.05 ± 0.01 arc-second.



Use of the two cylindrical rods on the left of the sine bar eliminates one major source of error due to the variable air films between a gage block in contact with plane metal surfaces above and below it. Such an air film might well be of the order of magnitude of the increments in the gage blocks. When a gage block is in position between the cylindrical rods as shown, there are only line contacts with the rods so that the air films are effectively eliminated. The V-groove surface is provided to minimize backward or forward displacement of the sine bar. This groove is lapped to the rod, so that the two surfaces make an 80 percent line contact through a minimum of 3 degrees of rotation. A thumbscrew may be provided on the support fixture close to the left end of the device, to permit the sine bar to be raised or lowered without lateral displacement.

Source: M. Thekaekora
Goddard Space Flight Center
(GSC-10438)

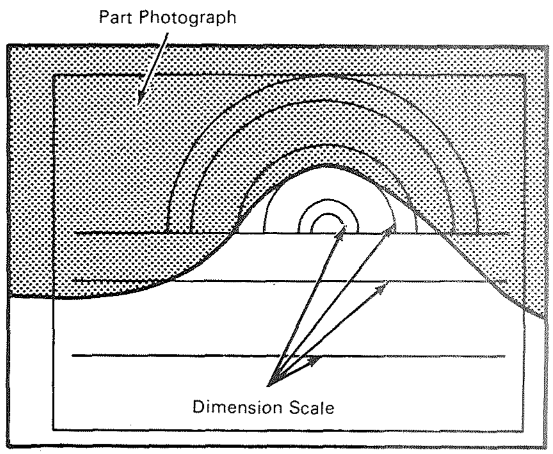
Circle 11 on Reader's Service Card.

PHOTOMICROMETROLOGY

It is necessary to determine accurately, the physical dimensions (angles, contours, etc.) of the microscopic details of very small components when they must meet exceedingly fine tolerances.

A method known as photomicrometrology that combines microphotography with standard measuring techniques makes this possible. Where a microphotograph cannot be directly applied due to the inaccessibility of the part involved, a mold can be used to determine the angle or contour of interest.

A photograph is taken through a microscope, set at a predetermined level of magnification, and the resultant negative is overlaid on an optical scale of the same magnification, as shown in the sketch. In those cases where the location of interest does not permit direct microphotography, a standard commercially available molding plastic substance is used to make a reverse contour which can be removed and photographed through the microscope. This microphotograph is then measured in the same way to give the desired results.



This technique has been successfully used to achieve proven measurements to 25 microinches.

Source: F. L. Young of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-14556)

Circle 12 on Reader's Service Card.

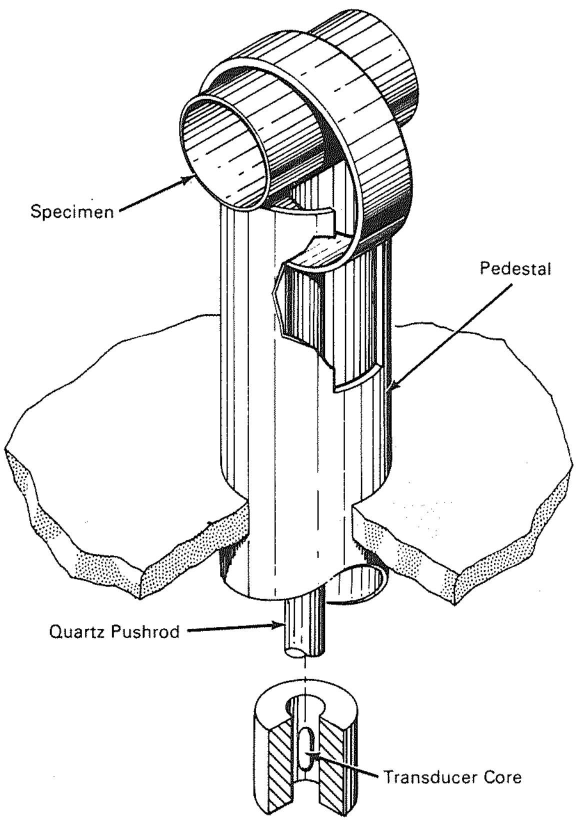
DIAMETRAL THERMAL EXPANSION MEASUREMENT OF TUBING

In order to measure the diametral thermal expansion of Ta/316 bimetallic tubing, a modified form of the standard quartz pushrod technique has been successfully used. In this application, one end of a quartz pushrod is attached to a ring that surrounds and contacts the tubular specimen at a point opposite a pedestal.

A vertical quartz tube having a flat, polished end serves as the pedestal within which the pushrod is mounted and upon which the specimen rests. The lower end of the pushrod is attached to the core of an electromechanical transducer. The coil of the transducer is mounted in the lower end of the pedestal. The pushrod is not subject to sliding friction since it hangs on the specimen and is capable of following very small dimensional changes in the specimen. Movement of the pushrod and transducer core causes a change in the coil output and this change is fed to a direct readout device.

Source: P. S. Gaal of
Westinghouse Astronuclear Lab.
under contract to
Lewis Research Center
(LEW-10851)

Circle 13 on Reader's Service Card.



INSTRUMENT ACCURATELY MEASURES HOLE CENTERLINES

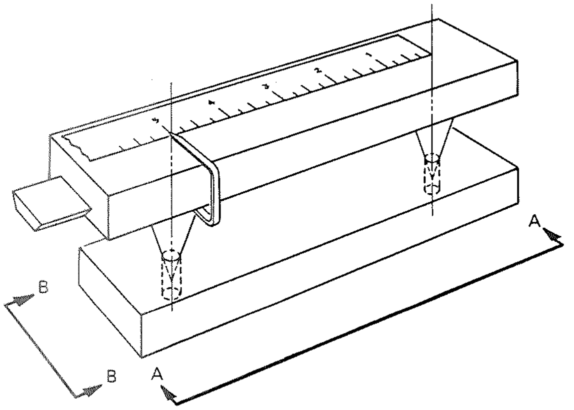


Figure 1

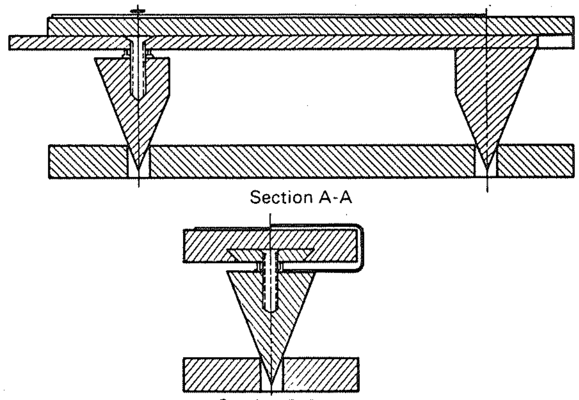


Figure 2

Determinating hole centerline distances previously involved three separate measurements and calculations. This introduced three potential error sources and required considerable time to accomplish. An instrument has been designed that permits hole centerline distance determinations

to be made directly, requiring no additional measurement or calculation.

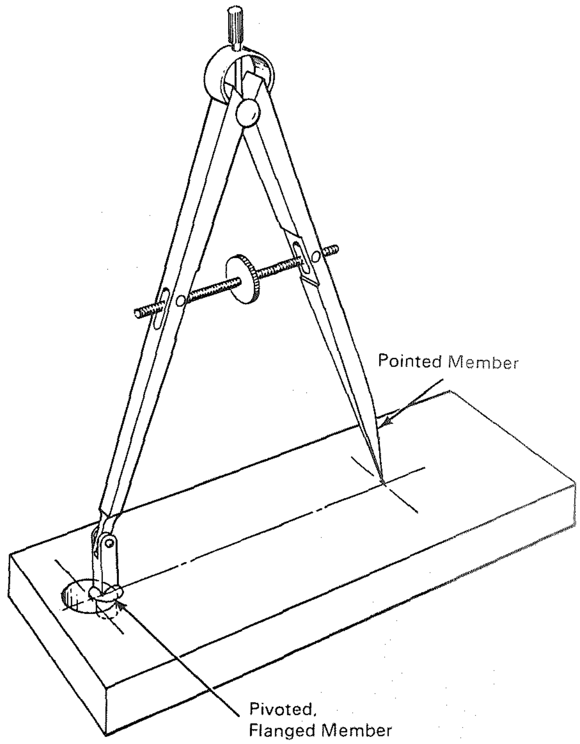
The hole centerline measurement instrument shown in Figure 1 uses cones to locate the centerlines of holes, and translates these locations to a scale. Cones are used because they will always seek hole centers throughout a wide range of diameters. One cone is attached to the zero end of the scale and the other is attached to a moveable slide in a channel. A pointer translates the center of the moveable cone, which is in the centerline of the hole it rests in, to the scale. Sectional views A-A and B-B of Figure 2 further illustrate the construction of the hole centerline measuring instrument.

Source: R. W. Lemke of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10226)

No further documentation is available.

INSTRUMENT ACCURATELY MEASURES DISTANCES FROM EDGES OR HOLES

An instrument has been designed to make accurate measurements from edges or holes without the necessity of extensive layout. When hermaphrodite calipers are used to make measurements from holes or edges, the inside or bowed leg is free to travel up or down the vertical surface. Such movement can result in inaccurate measurements or markings.



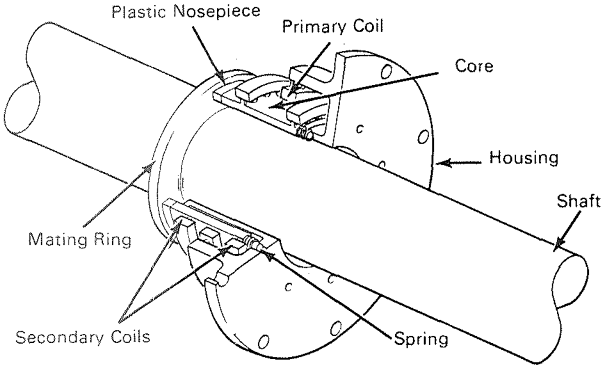
To eliminate this vertical movement of the bowed leg, the instrument shown in the figure substitutes a flange on a cylindrical pivoting end of one member in place of the bowed leg of the hermaphrodite caliper. This flange stops the instrument at the horizontal surface and permits the preset distance to the marking leg (pointer) to be maintained. In use, the modified caliper is set to the indicated distance by measuring from the inside of the flanged pivoting member to the tip of the pointed member. The measurement figure has one half the hole diameter added for a centerline measurement.

Source: R. W. Lemke of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10225)

No further documentation is available.

DIFFERENTIAL TRANSFORMER MEASURES AXIAL SHAFT LOAD OR DEFLECTION

An annular differential transformer has been designed to measure axial shaft load and deflection for rotating equipment. The transformer with a polytetrafluoroethylene nosepiece is attached to an axially movable core and mounted on the shaft. Direct measurements of axial movement of the shaft are provided.



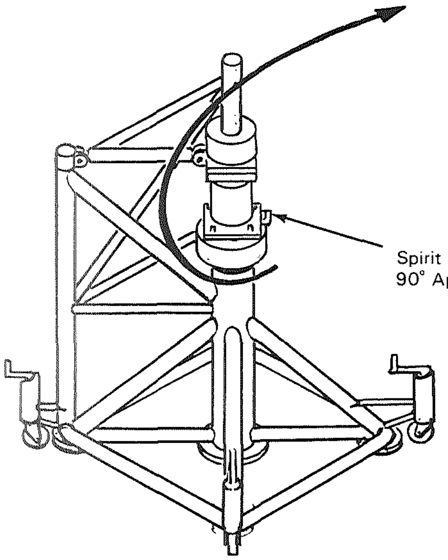
In operation, a highly polished mating ring (similar to a carbon nose bellows seal) is attached to the shaft. The differential transformer nosepiece is held in intimate contact with the mating ring by a number of light springs bearing against the body of the transformer. Axial movement of the shaft produces an equal movement of the nose and core, changing the magnetic flux established by the primary core which is stationary in the transformer housing. The voltage induced in the secondary coils by the core is measured as a delta voltage proportional to the core movement.

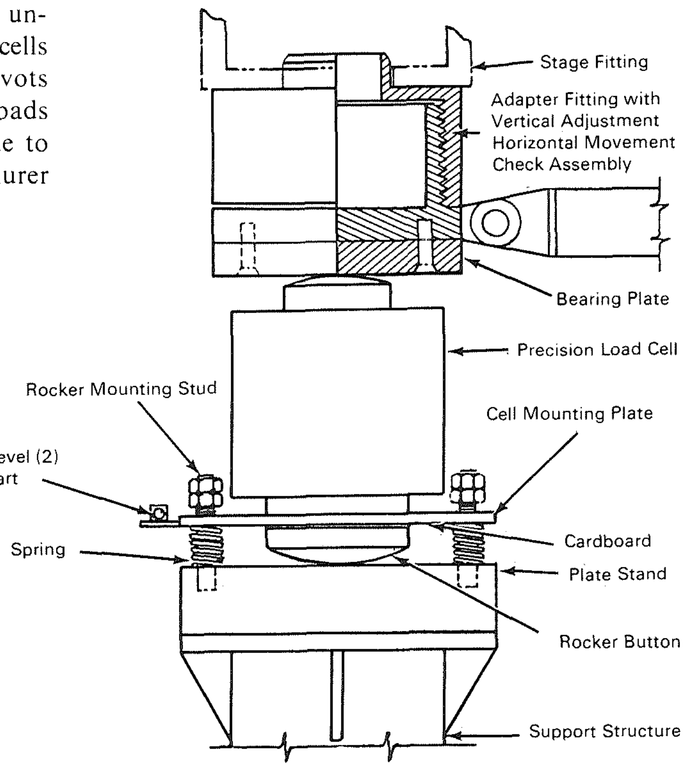
Source: C. A. Johnson of
North American Rockwell Corp.
under contract to
Marshall Space Flight Center
(MFS-13302)

No further documentation is available.

WEIGHING SYSTEM ASSURES AXIAL LOADING

Nonaxial loading is a primary cause of uncertainties and inaccuracies in using load cells for weighing large, heavy objects. Flexure pivots have been used successfully to handle such loads but cannot be used in many applications due to the excessive space required. One manufacturer





uses rocker assemblies and check links for truck and railroad scales, but investigation has shown that this installation allows the load cells to tilt with no means of determining the degree of tilt.

The sketch shows an improved weight stand that assures true axial loading determination. Three or more such stands are required to form a complete weighing system for large, heavy objects. Weight of the object resting on the stage fitting is brought to bear on the adapter fitting, and deflection in the object tends to impose horizontal loads on the installation. Horizontal movement check assemblies transmit these loads into the stand rather than to the load cell. If horizontal forces are sufficient to deflect the stand, or if there is play in the check assembly, the horizontal force applied to the load cell will cause the cell to tilt. When this occurs, the degree of tilt can be determined by the precision spirit levels. An angular tolerance can be established in calibrating the system since it has been found that minor deviations (less than 1.0°) have little effect on either accuracy or repeatability. This is also borne out in theory, since the loads sensed by the load cell are cosine functions of the angle between the load cell column and the vertical, as referenced to gravity.

The cardboard disk has improved repeatability from approximately ±0.05 percent to approximately ±0.025 percent by providing better load distribution into the bottom of the load cell. The rocker mounting studs and springs are used to adjust the cell mounting plate level under no-load conditions.

Source: L. G. Smart of
The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-91429)

Circle 14 on Reader's Service Card.

A METHOD TO OBTAIN SCALE FACTORS IN AXONOMETRIC ENGINEERING DRAWINGS

A table has been computed to provide foreshortened scale factors and projected ellipses for any axonometric cube in one-degree increments. This table, a small sample of which is shown, should be valuable in obtaining scale factors in axonometric engineering drawings. Present methods require a graphical development to determine the foreshortened scale factors and projected ellipses for a selected dimetric or trimetric pro-

Z TIMES TRUE DIMENSION = FORESHORTENED DIMENSION

ALPHA = 1

BETA	Z1	Z2	Z3	E1	E2	E3
1	0.99985	0.70721	0.70721	1.000	44.991	44.991
2	0.99970	0.81666	0.57764	1.415	35.248	54.715
3	0.99954	0.86625	0.50053	1.733	29.975	59.965
4	0.99939	0.89470	0.44803	2.002	26.530	63.382
5	0.99924	0.91320	0.40939	2.240	24.049	65.833
6	0.99908	0.92620	0.37947	2.455	22.151	67.699
7	0.99893	0.93584	0.35545	2.653	20.635	69.179
8	0.99877	0.94329	0.33565	2.839	19.389	70.388
9	0.99862	0.94921	0.31899	3.014	18.339	71.398
10	0.99846	0.95404	0.30476	3.180	17.437	72.256
11	0.99830	0.95806	0.29243	3.339	16.652	72.997
12	0.99814	0.96145	0.28163	3.492	15.960	73.642
13	0.99798	0.96436	0.27210	3.640	15.343	74.211
14	0.99782	0.96688	0.26362	3.783	14.787	74.715
15	0.99766	0.96909	0.25603	3.921	14.284	75.166
16	0.99749	0.97103	0.24919	4.057	13.824	75.570
17	0.99733	0.97277	0.24302	4.189	13.402	75.935
18	0.99716	0.97432	0.23741	4.319	13.012	76.266
19	0.99699	0.97573	0.23231	4.446	12.650	76.567
20	0.99682	0.97700	0.22765	4.572	12.312	76.841
21	0.99664	0.97816	0.22339	4.695	11.997	77.092
22	0.99647	0.97922	0.21949	4.817	11.700	77.321
23	0.99629	0.98020	0.21590	4.938	11.420	77.532
24	0.99611	0.98111	0.21261	5.058	11.156	77.725
25	0.99592	0.98194	0.20959	5.176	10.905	77.902
26	0.99573	0.98272	0.20681	5.294	10.666	78.064
27	0.99554	0.98345	0.20426	5.411	10.439	78.214
28	0.99535	0.98413	0.20192	5.528	10.221	78.351
29	0.99515	0.98477	0.19977	5.645	10.013	78.476
30	0.99495	0.98537	0.19781	5.761	9.813	78.591
31	0.99474	0.98593	0.19602	5.878	9.621	78.696
32	0.99453	0.98647	0.19439	5.995	9.436	78.791
33	0.99432	0.98698	0.19291	6.112	9.257	78.877

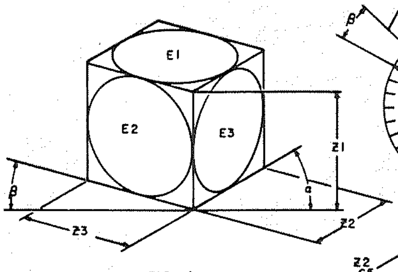


FIG. I

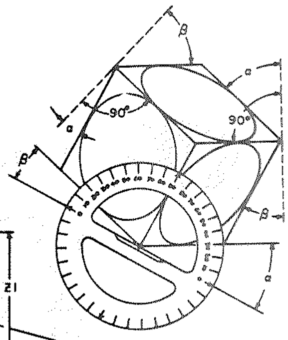


FIG. II

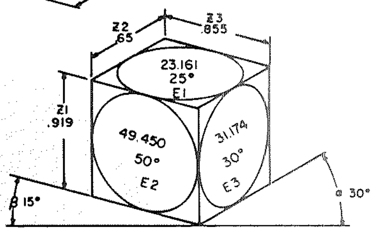


FIG. III

jection drawing. This innovation eliminates the graphical development requirement and offers immediate lookup of the scale factors and projected ellipses for a selected axonometric projection.

Computed for every alpha degree are all the beta degrees and six columns of numbers. Under the first three columns (Z1, Z2, Z3), are listed the foreshortening factors for the three axes of a cube, and the other three columns (E1, E2, E3) list the degree of the ellipses for the corresponding planes. This system provides every possible measurement factor and ellipse in one degree increments from zero to 90°.

Source: R. Chu of
North American Rockwell Corp.
under contract to
Manned Space Flight Center
(MSC-15829)

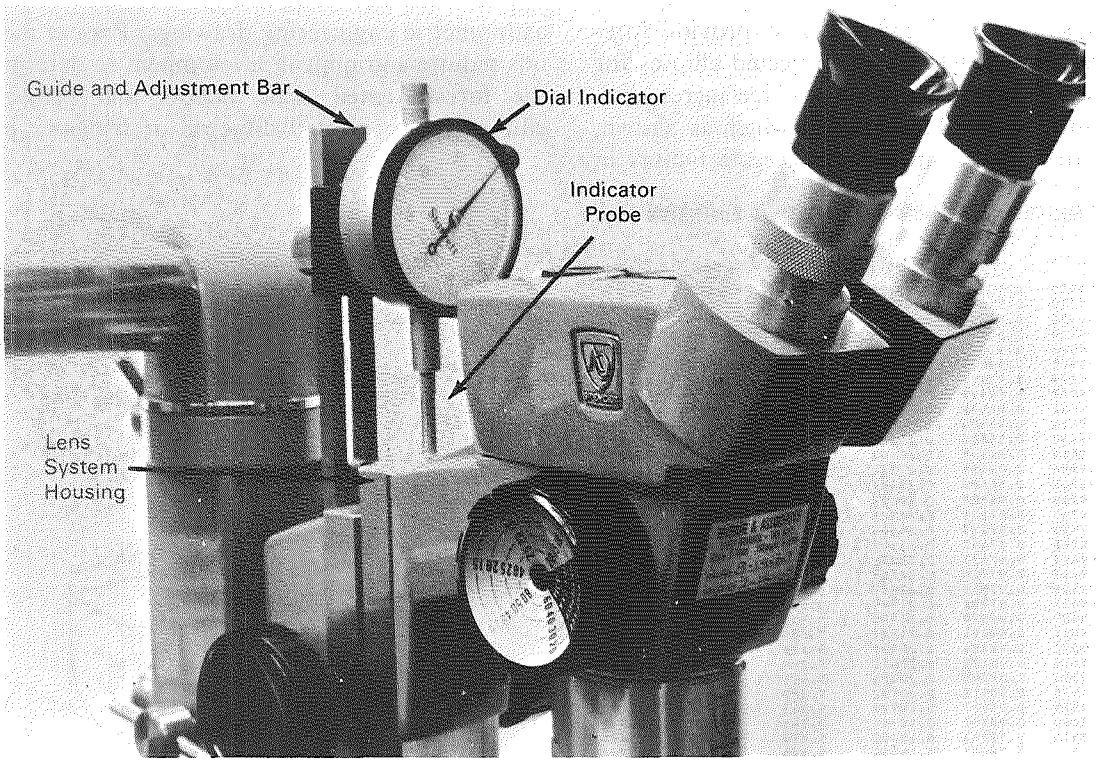
Circle 15 on Reader's Service Card.

MODIFIED MICROSCOPE PROVIDES DEPTH MEASUREMENT

The depth of voids, pits, or depressions in material test specimens can be measured nondestructively by a dial indicator and a wide-lens microscope. Prior methods involved destructive cross sectioning of the part or the use of a measuring instrument in conjunction with, but not attached to, the microscope. The modified microscope provides more accurate measurement, is easier to calibrate, and requires less handling of specimens by the operator than previous methods.

The adaptation equipment includes: a wide-field stereoscopic microscope, a calibrated micrometer dial indicator, and a dial indicator guide and adjustment bar. The rack and pinion head adjustment of the microscope is modified to allow installation of the dial indicator.

Depth measurements are carried out by the following procedure: The test specimen is secured under the microscope, and the lens system is adjusted until the surface of the specimen is in focus.



The dial indicator is lowered on the guide and adjustment bar until the indicator probe is in contact with the microscope lens system housing. The indicator dial is then adjusted to zero. When the lens system is lowered to focus on the bottom of the depression, pit, or void on the specimen, the adjustment for focus indicates the depth of the depression, which can be read directly from the micrometer dial indicator.

The modified microscope is accurate to 0.0001 inch.

Source: L. W. Jackson of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-91223)

No further documentation is available.

SYSTEM MEASURES LINEAR AND ANGULAR DIMENSIONS OF VERY LARGE STRUCTURES

A system has been developed that will enable accurate and rapid measurement of linear and angular dimensions of very large structures of any configuration.

A precision rotary table has been combined with an integrated optical tooling bar system that can be used for measurement of structures with horizontal dimensions of up to 45 feet and a maximum height of 30 feet. Linear dimensions can be rapidly measured to an accuracy of 0.005 inch, and angular dimensions can be measured to within 2 seconds of arc.

The structure to be measured is mounted on the turntable which can be rotated 360° to expose any desired surface to sighting by the optical tooling bars. The table turns on a bearing which is fully compensated by pressurized fluid in both the radial and thrust planes. The bearing provides a precise, stable, essentially frictionless axis of rotation and will support a weight of up to 40 tons.

There are three tooling bars, two horizontal and one vertical, which are located around the periphery of the turntable. The horizontal tooling bars are stationary and situated 90 degrees to each other along two sides of the turntable. The vertical tooling bar is mobile and located at the outer end of one of the horizontal tooling bars. Using lateral adjusters mounted on the table, the structure to be measured is centered to within 0.005 inch (total indicated reading). The structure can then be rotated while maintaining a parallel relationship to the horizontal tooling bars and a perpendicular relationship to the vertical tooling bar. Linear measurements are made through the use of master indexing bars on each of the tooling bars, with the table in a stationary position. Angular measurements are made by rotating the table with respect to a stationary point on one of the tooling bars.

The equipment includes readout systems that provide direct linear and angular indications. The linear readout is in inches, and the angular readout is in degrees, minutes, and seconds.

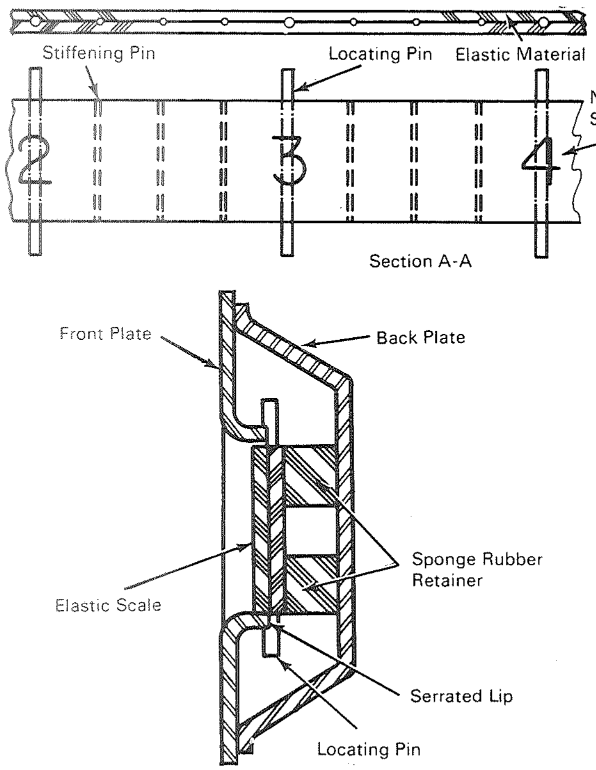
Source: R. R. Simpson of
The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-92477)

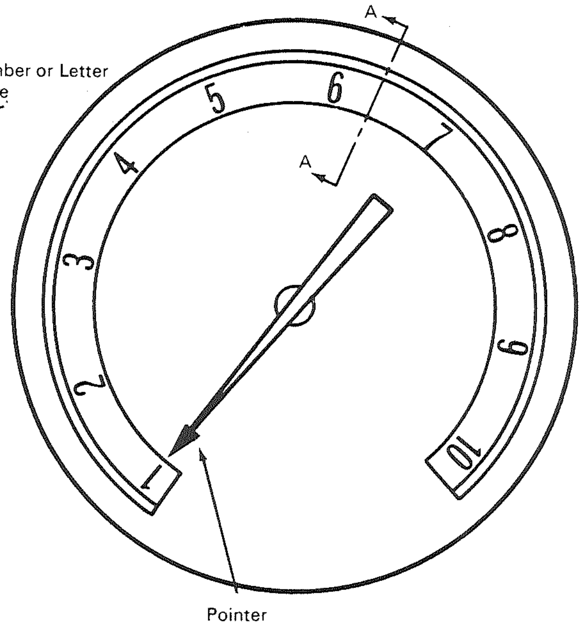
Circle 16 on Reader's Service Card.

ADJUSTABLE DIAL SCALE

An elastic scale permits readout dials to be easily adjusted so that they indicate true calibrated values. Previously, readout dials were calibrated by means of charts or curves; instrument values were taken and true values determined secondarily from the gathered data.

The components of the adjustable dial scale are shown in the illustration. To construct the device, strips of bonded elastic material which contain both locating and stiffening pins, are prepared according to the required dimensions of the instrument in use. A number or letter scale with the





appropriate range is marked on one side of the elastic material. The scale is then secured on the readout dial by a front plate, back plate, and retainer.

The instrument is calibrated and the dial scale adjusted by moving the locating pins around a serrated lip on the front plate of the dial face until the pointer reads the true values.

The holder device for the elastic scale may be incorporated either as a part of the instrument face or as a separate item attached to the instrument. The stiffening pins and bonded configuration of the elastic scale cause it to stay in the desired position and maintain uniformity in the dial value increments, after the adjustment.

Source: C. A. Minton and E. D. Wallace
Kennedy Space Center
(KSC-66-5)

No further documentation is available.

SYSTEM FOR MEASURING ROUNDNESS AND CONCENTRICITY OF LARGE TANKS

Equipment has been under development for measuring the roundness and concentricity of large, massive tanks. The equipment includes a 34-foot rotary table, a variable reluctance displacement transducer, an electronics console, a digital computer, and a 5-foot plotter used for final data display. Operation of the system is relatively simple and straightforward. Test results indicate that a measurement accuracy of 0.003 inch is readily attainable on a 34-foot diameter (7.36×10^{-4} percent accuracy).

In making measurements on a large tank positioned on the rotary table, the variable reluctance transducer is positioned against the tank through a precisely ground cam. As the rotary table moves the tank past the cam, any deviation from a preset zero reference point correspondingly changes the reluctance of the transducer. The resultant output voltage, corresponding to the deviation, is fed through a signal conditioning amplifier to a calibration panel. The output from the calibration panel is a direct analog in millivolts per inch of deviation.

This analog voltage is passed to a digital voltmeter where the signal is displayed as inches of deviation and processed into a binary coded decimal format. While these measurements are being made, an angular readout unit displays 0.1-degree increments of rotation of the rotary table. Data from the readout unit are fed to a logic panel and to a preprogrammable counter. The counter may be programmed to allow readings at any multiple of degrees or tenths of degrees, enabling the inspector to make from 1 to 36,000 measurements per rotation of the table. The counter also supplies speed information to the central logic system.

The measurement data are coded on tape, giving the deviation of any specific point and the rotational speed of the table at the time the reading was taken. The taped data are converted into an acceptable form for the large plotter. A pattern of the tank is then plotted showing all deviations from the reference point.

To measure the vertical concentricity of the tank, it is only necessary to take a set of readings at two or more axially perpendicular planes through the tank and plot the resultant circles on the large plotter.

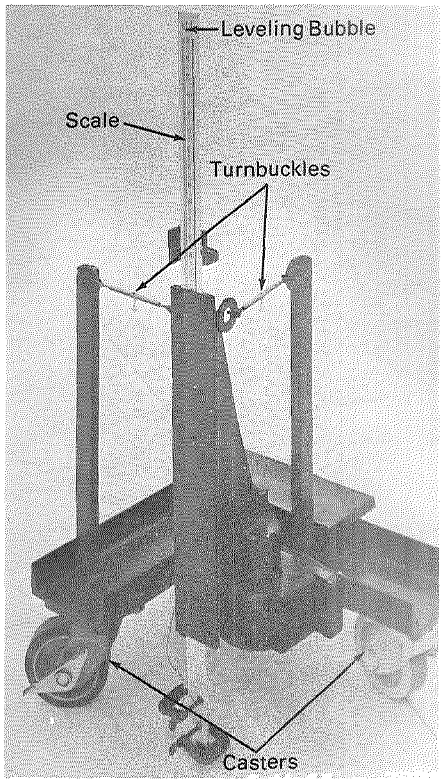
Source: R. E. Melton of
SPACO, Inc.
under contract to
Marshall Space Flight Center
(MFS-13362)

No further documentation is available.

ADJUSTABLE SCALE POSITIONER HOLDS TRUE VERTICAL POSITION

A leveling bracket has been developed for positioning a steel scale in a true vertical position. The device consists of a caster-mounted tripod base and an adjustable ball and socket mount which permits adjustment of the scale vertical attitude by means of two turnbuckles mounted at right angles to the scale.

The scale is located and clamped in the slotted area of the positioner with the bottom of the scale resting on the surface where flatness is to be determined. A leveling bubble is located in the upper portion of the scale. The turnbuckles are adjusted and the leveling bubble is used to locate the scale in a true vertical position. Optical readings can then be taken through a sight level to the scale with the scale maintained in a rigid position, thus eliminating the movement that occurs when the scale is hand-held. Once the scale has been set, readings desired in other locations can be taken by rolling the positioner from place to place.



Source: Ronald J. Mohr of
North American Rockwell Corp.
under contract to
Manned Spacecraft Center
(MSC-15623)

No further documentation is available.

NASA-Langley, 1971

"The aeronautical and space activities of the United States shall be conducted so as to contribute . . . to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

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